4.1 HYDROLOGY: PRECIPITATION AND FLOW

Total annual rainfall during the 2000-2001 storm season in LA County was just below normal. The long term average annual rainfall at Station # 716, Ducommun Street in downtown Los Angeles is about 15.60 inches. For water year (WY) 2000-2001 the total rainfall from October 2000 through May 2001 was about 15.09 inches.

Figures 4-1a and 4-1b show the rainfall pattern for WY 2000-2001 compared to the long term pattern of rainfall. About 78% of the annual total fell during the month of January. This is reflected by the timing of the storms that were monitored. Seven of the 12 storms monitored occurred in January and February. The months of November and December were practically dry this season while February had more than twice the amount of rainfall compared to the long term average for that month.

Table 4-1 summarizes the hydrologic and meteorologic conditions of each station-event monitored this season. Table 4-2 summarizes total precipitation and runoff volume for each station on a seasonal basis from 1994 through 2001. These data will help define hydrologic and water quality trends after subsequent years of data are compiled. A collection of 2000-2001 season hydrographs for each storm event from the monitored sites and rainfall contour maps is included in Appendix A. Each hydrograph includes the time of grab sample collection when applicable, the time of the first and last composite sample aliquot collection, the number of aliquots per composite, the sample volume interval, and the percent of storm sampled.

Also included in Appendix A are contour maps of total rainfall for the 2000-2001 storm season. The dates given as "Storm Event Date" are the dates each storm began.

4.2 STORMWATER QUALITY

A summary of the composite and grab samples taken during the 2000-2001 season is included as Table 4-3.

4.2.1 Determination of Constituents of Concern for Analysis

The County analyzes for some 209 individual water quality constituents, the results of which are included in Appendix B. But while the Municipal Stormwater permit lists 25 of them as constituents of concern, some constituents were not detected or were detected at levels below a number of common water quality guidelines. Therefore, a comparison was made between mass emission water quality results and the water quality objectives outlined in the Ocean Plan, Basin Plan, and California Toxics Rule. If either the mean or median concentration of a constituent from mass emission sampling exceeded the objective, it was selected for further analysis. The 2000-2001 mass emission results were compared with the standards in Table 4-4a, while information about each site is included in Table 4-4b. A comparison was made of the 1994-2001 water quality concentrations, and 17 pollutants were identified (see Table 4-4c). A complete description of the comparison study is included in *Los Angeles County 1994-2000 Integrated Stormwater Monitoring Report* (Los Angeles County Department of Public Works). Thirteen additional constituents (total suspended solids, diazinon, chlorpyrifos, total coliform, fecal coliform, fecal streptococcus, fecal enterococcus, dissolved phosphorus, total phosphorus, ammonia nitrogen, nitrate nitrogen, nitrite nitrogen and TKN, which may have not exceeded

standards or did not have standards defined) were also included. The constituents used for analysis are:

- Total Aluminum
- Dissolved Cadmium
- Dissolved Copper
- Total Copper
- Dissolved Nickel
- Total Nickel
- Dissolved Lead
- Total Lead
- Total Mercury
- Dissolved Zinc
- Total Zinc
- Total Suspended Solids
- Total Dissolved Solids
- Total Kjeldalh Nitrogen
- Ammonia

- Cyanide
- Turbidity
- Diazinon
- Chlorpyrifos
- Dissolved Phosphorus
- Total Phosphorus
- Total Coliform
- Fecal Coliform
- Fecal Streptococcus
- Fecal Enterococcus
- Bis(2-ethylhexyl)phthalate
- Phenanthrene
- Pyrene
- Nitrate
- Nitrite

The above 30 constituents of concern were used in developing the percentile distribution (box and whisker) graphs, bacteria count trend analysis, and pollutant loading estimations.

There are no numerical effluent standards that apply to stormwater pollution. Current federal and state numeric effluent standards apply only to "point source pollution," such as sanitary sewage, industrial and commercial discharges to the ocean, and other waterbodies. Water quality standards described in the 1995 Los Angeles Region Basin Plan or the 1997 California Ocean Plan do not apply to stormwater runoff, and any exceedance of values should not indicate violation or noncompliance with the plans. The 2000 California Toxics Rule is, strictly speaking, applicable to industrial and sewage treatment plant point-source discharges, but not to stormwater runoff discharges, which do not have any effluent limits. Furthermore, a direct comparison of the sampling results with the Ocean Plan standards cannot be made since the results presented in the tables are detected values before dilution, a factor allowed by the Ocean Plan. At the same time, however, it should be noted that new stormwater permits are including the narrative guidelines and limitations prescribed in the local Basin Plans.

4.2.2   Mass Emission Element

The NPDES Municipal Stormwater Permit mandates that the County monitor the quality of its stormwater discharges and create various programs for managing and improving stormwater runoff quality. The permit specifically requires the County to assess the pollutant loading from all six of its Watershed Management Areas following the 2000-2001 storm season.

4.2.2.1 GIS Model

To assist in implementing this requirement, the Department developed a GIS application called the Pollutant Loading Model.

The Pollutant Loading application computes total pollutant loading for selected pollutants originating in user-defined watersheds or political boundaries. It draws upon many existing data sources, such as predetermined drainage subbasins, land use, historical and event rainfall data, water quality monitoring station results, and multiple underlying geographic data including political boundaries, natural boundaries, census tracts, forest boundaries, streets, and drains.

Assumptions and Limitations

- An imperviousness value used for the calculations is associated with 104 different land use categories.

- The 104 SCAG land use categories have been aggregated into 34 categories covering 100% of the County.

- Water quality data collected from 8 different land use monitoring stations yields Event Mean Concentration (EMC) values. The remaining land use categories (34-8 = 26) use assumed EMC values based on their association with the 8 monitored land use types.

- All polygons of the same land use type are assumed to have the same EMC value regardless of their spatial location within the county.

- Annual pollutant loadings use previously calculated seasonal EMCs for their calculation.

- Rainfall grid cell sizes are 500 feet by 500 feet. Rainfall depth does not vary within the grid cell.

- The model does not account for variation over time in soil permeability which influences surface runoff in undeveloped watersheds. In other words, a given coefficient of discharge for a particular land use type will not change regardless of previous soil conditions (saturated soil versus dry soil)

The model does not take into account possible degradation or adsorption of the pollutant as it is transported downstream. These results therefore should not be taken as absolute; rather, they should be used for unmonitored watersheds or smaller portions of monitored watersheds for comparative purposes only.

4.2.2.2 Mass Emission Water Quality

This section provides a description of wet-weather results generated during the 2000-2001 monitoring season (Figures 4-2a through 4-2u). The figures present several panels, one for each parameter, with a series of box and whisker plots, one for each constituent. This box and whisker presentation of the data provides information on the distribution and variability of each data set. It shows the median, mean, 25 and 75 percentiles, 10 and 90 percentiles, as well as the 5 and 95 percentiles. Common water quality objectives for each parameter are also provided where available.

The criteria and conventions used in generation of these statistics are as follows:

- Only datasets that had at least 20% "detections" (positive result, with value above the method detection limit), and at least three "detections", were included;

- For data sets that met the selection criteria, if a parameter was a "non-detect", i.e., under the method detection limit, it was included in the dataset as half the method detection limit.

Thus, absence of a plot for a specific station for a given parameter may indicate that the dataset did not meet the selection criteria. However, in some situations it may indicate lack of data (due to logistical constraints related to sampling activities). The reader is referred to Table 4-3 for data inventory information.

All data for mass emission stations are presented in Appendix B.

- Malibu Creek had noticeably higher median concentrations of both total and dissolved phosphorus, while the San Gabriel River has the highest median concentration of nitrate.

- The median total dissolved solids concentration in Malibu Creek is more than twice that of any other mass emission sites.

- Both total and fecal coliforms exhibited higher medians in the Los Angeles River. Ballona Creek had the greatest range of results for both total and fecal coliforms as well as fecal enterococcus, while the Los Angeles River had the greatest variablilty for fecal streptococcus results. Please see Table 4-5 and Figures 4-3a through 4-3d for bacteria counts from 1994-2001.

- Concentrations were similar among stations for a given metal. In other words, no station appeared to be "cleaner" or "dirtier" than any other with respect to metals.

- There were several individual exceedances of water quality objectives, either of the California Toxics Rule or of the Ocean Plan (or of both), for metals; and in fact, total aluminum, total copper, dissolved copper, and total zinc each had at least one seasonal mean or median exceed an objective.

The Permit states that if a given constituent is not detected in at least 25% of the samples taken in ten consecutive storm events at a given station then that constituent may qualify for removal from the analytical suite for the associated station. Several mass emission stations meet this criterion and are summarized in Table 4-6. It is recommended that these constituents be removed from the analytical suite for the associated stations.

4.2.2.3 Loadings for Constituents of Concern for 2000-2001 Storm Season

Derivation of Event Mean Concentrations

Section B.4 of Attachment C of the Municipal Stormwater Permit (CAS614001) requires the County to "perform a loads assessment analysis for each of the six Watershed Management Areas to determine pollutant loads entering the ocean from receiving waters in the county . . . using the collected monitoring data from the land use and mass emission stations . . . and employing the USEPA simplified model". The work plan for this assessment, submitted to the Regional Board on November 6, 1997, was described in detail in *Monitoring Task Report No. 2* (Woodward-Clyde, December 9, 1996b). Loads from monitored mass emission watersheds have been calculated from observed mass emission mean concentrations and runoff volumes. Loads

from unmonitored watersheds have been estimated using the GIS loading model with mean concentrations derived from the land use monitoring program. Following is a brief explanation of how event mean concentrations were calculated.

The event mean concentration is based on flow-weighted composited samples. Numerous data sets were created comprised of laboratory results from each monitoring station for a given season. Data were screened and analyzed to determine the quality and amount of data present. The following criteria were applied:

- at least 20% of the sample results were detected concentrations;

- there were at least 3 detected sample concentrations.

If the set of data did not meet these criteria, it was not used to calculate an event mean concentration. If sufficient data existed to conduct the statistical analysis, two methods were followed to address non-detects.

Initially, the Hazen robust method was used to calculate land use EMCs. The robust method uses a combination of regression and probability analysis to determine the "assumed" concentration to assign to samples with concentrations below the method detection limit. The "assumed" concentration is the point along a probability distribution regression line (derived from detected data) where true concentrations of non-detected data have the highest probability of residing. Each non-detect result was assigned the value of the detection limit and ranked along with the other detected results in the data set. The cumulative frequency data were plotted on a logarithmic plot and a straight line regression was fitted to the points. The mean, m, and variance, s^2, of the natural logarithm of each point of the data set were used to calculate the event mean concentration. The event mean concentration, which the loading model multiplies by the volume of the event runoff to develop total loading, is defined as follows:

Event Mean Concentration $= \exp(m + 0.5 s^2)$.

In order to reduce analysis time, another method, which has been successfully implemented by other agencies, was also used to calculate EMCs for the mass emission water quality data. That second method assigned a value of half the detection limit to each non-detect result. The resulting data set of concentrations was analyzed as described above to develop the mass emission EMCs. A comparison of the two methods showed that differences between EMCs developed from the same data set were insignificant in most cases; therefore, the second method assumed a valid approach.

The calculated EMCs are summarized in Table 4-7 for specific land uses. These EMCs were used to estimate loadings for several watersheds.

The loadings calculated for the monitored watersheds are summarized in Tables 4-8a through 4-8e and Figures 4-4a through 4-10.

The locations of unmonitored watersheds are shown in Figures 4-11 through 4-13. The loadings calculated for the unmonitored watersheds are summarized in Tables 4-9a through 4-9c and Figures 4-14 through 4-16.

4.2.3   Land Use Element

The land use element monitoring results for the 2000-2001 season are summarized in Table 4-10. This table includes the number of samples analyzed and the percentage of samples that had detectable concentrations, as well as summary statistics (the mean, median, and coefficient of variation (CV)). Box and whisker plots for several constituents are included as Figures 4-17a through 4-17v for the 2000-2001 season. This "box-and whisker" presentation of the data provides information on the distribution and variability of each data set. It shows the median, mean, 25 and 75 percentiles, 10 and 90 percentiles, as well as the 5 and 95 percentiles. Common water quality objectives for each parameter are also provided where available.

The criteria and conventions used in generation of these statistics are as follows:

- Only datasets that had at least 20% "detections" (positive result, with value above the method detection limit), and at least three "detections", were included;

- For data sets that met the selection criteria, if a parameter was a "non-detect", i.e., under the method detection limit, it was included in the dataset as half the method detection limit.

All data for land use monitoring stations are presented in Appendix B.

Thus, absence of a plot for a specific station for a given parameter may indicate that the dataset did not meet the selection criteria. However, in some situations it may indicate lack of data (due to logistical constraints related to sampling activities). The reader is referred to Table 4-3 and to the summary tables for data inventory information.

The median pH values were visibly different between catchment types, and this trend is also reflected in the median concentrations of bicarbonate. Runoff from the vacant catchment had high pH (8.0) and high alkalinity (median of 180 mg/l), while runoff from the light industrial, transportation, mixed residential, and high density residential stations had lower median pH values (6.9, 6.8, 6.8, and 6.8 respectively) and lower median alkalinity concentrations (26, 21, 26, and 23 mg/l respectively). The educational and multiple family residential stations fell in between these two extremes with median pH values of 7.1 and 7.3 respectively, and median alkalinities of 31 and 48 mg/l respectively.

Hardness is also an important variable of water quality because it diminishes the potential of dissolved metals to cause toxicity to aquatic life. Median hardness concentrations are similar to the alkalinity pattern: high (200 mg/l) at the vacant station; low in the transportation (30 mg/l), mixed residential (40 mg/l), and high density residential stations (20 mg/l); and in between (55, 60, and 75 mg/l) at the educational, light industrial, and multiple family residential stations.

Total suspended solids (TSS) measurements reflect the amount of sediment in the water. Sediment is a constituent of concern because of the potential to adversely affect the aquatic habitat and also cause sediment accumulation that ultimately may require dredging. Sediment also may be a carrier of other chemicals that have a tendency to adsorb to particulate matter. TSS results overlapped substantially among the different land uses; however, the light industrial station had the highest median for TSS (199 mg/l) being more than twice as high as the next highest median (84 mg/l for transportation).

Metals in stormwater runoff can be of concern because some metals are toxic to aquatic organisms and some can bio-accumulate in the tissues of aquatic organisms (e.g., fish and clams) and be a human health concern. Total and dissolved copper concentrations overlapped among

the different land uses, however, the dissolved copper median for the transportation station (31.6 µg/l) was more than twice as high as the next highest median (9.0 µg/l for mixed residential). Dissolved copper generally exceeds the 3.1 µg/l California Toxics Rule guideline while both mean and median concentrations of total copper exceed the Ocean Plan guideline in the transportation, light industrial, educational high density single family residential, and mixed residential stations. Total lead results are fairly consistent among land uses. Dissolved and total zinc exhibit similar patterns; there is substantial overlap among the different land uses although the mean and median for the light industrial station is highest in each case. All data for land use monitoring stations are presented in Appendix B.

The Permit states that if a given constituent is not detected in at least 25% of the samples taken in ten consecutive storm events at a given station then that constituent may qualify for removal from the analytical suite for the associated station. Several land use stations meet this criterion and are summarized in Table 4-11. It is recommended that these constituents be removed from the analytical suite for the associated stations.

The Permit allows the discontinuation of monitoring at a land use station for specific constituents once the event mean concentration (EMC) is derived at the 25% error rate. We used the mean standard error as a substitute for error rate as mutually agreed upon with the RWQCB (Swamikannu, 1999).

The constituents evaluated include:

- PAHs
- Copper
- Chromium
- Selenium
- Total Phosphorus
- Chlorpyrifos
- Total DDTs

- Chlordane
- Nickel
- Silver
- Mercury
- TSS
- Malathion
- Total PCBs

- Cadmium
- Lead
- Zinc
- Total Nitrogen
- Diazinon
- Simazine

We first identified 114 station-constituent combinations which had at least 10 detected samples and no more than 20% non-detected samples. Non-detects were replaced with half of the corresponding detection limit. Then, we performed the Shapiro-Wilk Normality Test at 5% significance level on each station-constituent to determine whether the concentrations were normally or lognormally distributed (Gibbons 1994, USEPA 1995). If the p-value of the normality test in raw scale of the constituent's concentration was greater than 0.05, such station-constituent was concluded to be normally distributed. Similarly, if the p-value of the normality test in log-transformed scale was greater than 0.05, it was concluded to be lognormally distributed. If a station-constituent was determined to be both normally and lognormally distributed (the p-values for both tests for normality were greater than 0.05), we assigned such station-constituent with a normal distribution. Similarly, if a station-constituent was neither normally nor lognormally distributed based on the normality tests (both p-values less than 0.05), we assumed that it had a normal distribution.

Based on the probability distribution determined above, we calculated the mean standard error as follows:

$$\text{Mean Standard Error} = \frac{\text{Standard Error}}{\text{Mean}} = \frac{\text{Standard Deviation} / \sqrt{\text{Sample Size}}}{\text{Mean}}$$

For those station-constituents with a normal distribution, the sample mean and standard deviation were used in the above formula. However, for station-constituents with a lognormal distribution, the mean and standard deviation were estimated as follows (Gilbert 1987):

$$\text{Mean, } \hat{m} = e^{(\overline{y} + \frac{s_y^2}{2})}$$

$$\text{Standard Error, } s(\hat{m}) = \sqrt{e^{(2\overline{y} + \frac{s_y^2}{n})}\left[\left(1 - \frac{2s_y^2}{n}\right)^{-\frac{(n-1)}{2}} \cdot e^{(\frac{s_y^2}{n})} - \left(1 - \frac{s_y^2}{n}\right)^{-(n-1)}\right]}$$

where $\overline{y}$ and s_y^2 are the arithmetic mean and variance of the log-transforme d values

n is the sample size

All results of this analysis are summarized in Table 4-12. Of 114 station-constituents under investigation, 25 of them had an EMC with a mean standard error higher than 25%. In other words, there were 25 station-constituents which had a standard error (standard deviation of the mean) larger than 25% of their corresponding mean concentrations. These station-constituents must continue to be monitored under the current Permit. The remaining 89 station-constituent combinations met the criteria and it is recommended that monitoring be discontinued for these constituents at the associated stations.

4.2.4   Critical Source Element

The following is a discussion of the results of the 2000-2001 critical source study results summarized in Table 4-13. This table includes the number of samples analyzed and the percentage of samples that had detectable concentrations, as well as summary statistics (the mean, median, and coefficient of variation (CV)). Box and whisker plots for several constituents are included as Figures 4-18a through 4-18q for the 2000-2001 season. This "box and whisker" presentation of the data provides information on the distribution and variability of each data set. It shows the median, mean, 25 and 75 percentiles, 10 and 90 percentiles, as well as the 5 and 95 percentiles. Common water quality objectives for each parameter are also provided where available. This was the second year BMPs were installed under the Critical Source Monitoring Program.

Note there are no numerical effluent standards that apply to stormwater pollution. Current federal and state standards apply only to "point source pollution," such as sanitary sewage, industrial and commercial discharges to the ocean and other water bodies. Water quality standards described in the 1995 Los Angeles Region Basin Plan or the 1997 California Ocean Plan do not apply to stormwater runoff, and any exceedance of values should not indicate

violation or noncompliance with the plans. The Toxic Rule is, strictly speaking, applicable to industrial and sewage treatment plant point-source discharges, but not to stormwater runoff discharges, which do not have any effluent limits. The Ocean Plan objectives apply to "instantaneous" grab samples. Furthermore, a direct comparison of the sampling results with the Ocean Plan standards is not directly applicable since the results presented in the tables are detected values before dilution, a factor allowed by the Ocean Plan. At the same time, however, it should be noted that new stormwater permits are including the narrative guidelines and limitations prescribed in the local Basin Plans.

The chemical constituents whose means were above the objectives of the Ocean Plan, Basin Plan, or California Toxics Rule are discussed below and are as follows:

- Bis(2-ethylhexyl)phthalate (a semi-volatile organic)

- Dissolved copper

- Total copper

- Total lead

- Dissolved nickel

- Dissolved zinc

- Total zinc

The testing methods for the critical source program are outlined in Section 3.

A comparison of control to test sites for the motor freight companies reveals the following.

- Median oil and grease concentrations were higher at the test sites (5.50 mg/l) than the control sites (1.80 mg/l).

- Median bacterial counts for all bacterial types examined were lower at the test sites than the control sites.

Sample sizes for the oil and grease samples as well as the bacterial samples were significantly higher (n=12 to n=21) than for the other analyses discussed (n=3). Therefore, caution must be used in applying the following observations.

- Median suspended solids concentrations were higher at the test sites (147 mg/l) than the control sites (73 mg/l).

- Median zinc concentrations, both total and dissolved, were higher at the test sites (245 and 178 mg/l ,respectively) than the control sites (157 and 110 mg/l, respectively).

- Median total aluminum concentrations were lower at the test sites (318 mg/l) than the control sites (635 mg/l).

- Median iron concentrations, both total and dissolved, were lower at the test sites (270 and 200 mg/l, respectively) than the control sites (920 and 320 mg/l, respectively).

A comparison of control to test sites for the auto dealers reveals the following.

- Median oil and grease concentrations were lower at the test sites (1.45 mg/l) than the control sites (3.7 mg/l).

- Median bacterial counts for all bacterial types examined were higher at the test sites than the control sites.

Sample sizes for the oil and grease samples as well as the bacterial samples were significantly higher (n=8 to n=16) than for the other analyses discussed (n=2 to n=3). Therefore, caution must be used in applying the following observations.

- Median suspended solids concentrations were lower at the test sites (46.5 mg/l) than the control sites (125 mg/l).

- Median zinc concentrations, both total and dissolved, were lower at the test sites (85.7 and 54.7 mg/l, respectively) than the control sites (150 and 133 mg/l, respectively).

- Median iron concentrations, both total and dissolved, were higher at the test sites (240 and 110 mg/l, respectively) than the control sites (110 and 50 mg/l, respectively).

The 2000-2001 season was the first year for which BMPs were implemented at the test sites for the motor freight and automobile dealership industries. Motor freight and automobile dealership industries had both active test and control sites this season for the first time. A list of initial BMPs purchased is included as Table 4-14. Individual business owners were encouraged throughout the storm season to use the BMPs at all times, although LACDPW had no control over this action on the part of the owners.